Award Number: 03HQGR0092

CONTINUOUS BROADBAND MONITORING OF STRAIN CHANGES NEAR ACTIVE FAULTS IN SOUTHERN CALIFORNIA

April 1, 2003 — March 31, 2004

Final Technical Report — Submitted September 15, 2004

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Program Element: II

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Abstract

This grant supports operation of the facilities at Piñon Flat Observatory (PFO) that measure crustal deformation in Southern California for periods from seconds to years. During the period of this grant, operations of the observatory continued as in the past, though with improvements to the local telemetry, and (with NSF funding) to one of the strainmeters. There were no significant strain changes associated with local earthquakes.

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1. Investigations and Results

This grant supports operation of the facilities at Piñon Flat Observatory (PFO) that measure crustal deformation in Southern California for periods from seconds to years. At this site, close to the San Jacinto and San Andreas faults, we have long-base strainmeters and tiltmeters whose sensitivity and stability are unmatched anywhere else. The long time over which these data have been gathered, and the multiple measurements available, give the results a strength that is difficult to achieve in this field. These measurements are relevant to the NEHRP program because they contribute to our understanding of the seismic cycle and how stresses accumulate on faults: for this, there is no substitute for a detailed, extended time history. The measurements from PFO now encompass a lengthy period of enhanced seismic activity (from 1986 on), including the two largest earthquakes in Southern California since 1952. The PFO measurements continue to provide a check on any possible strain anomalies throughout Southern California.

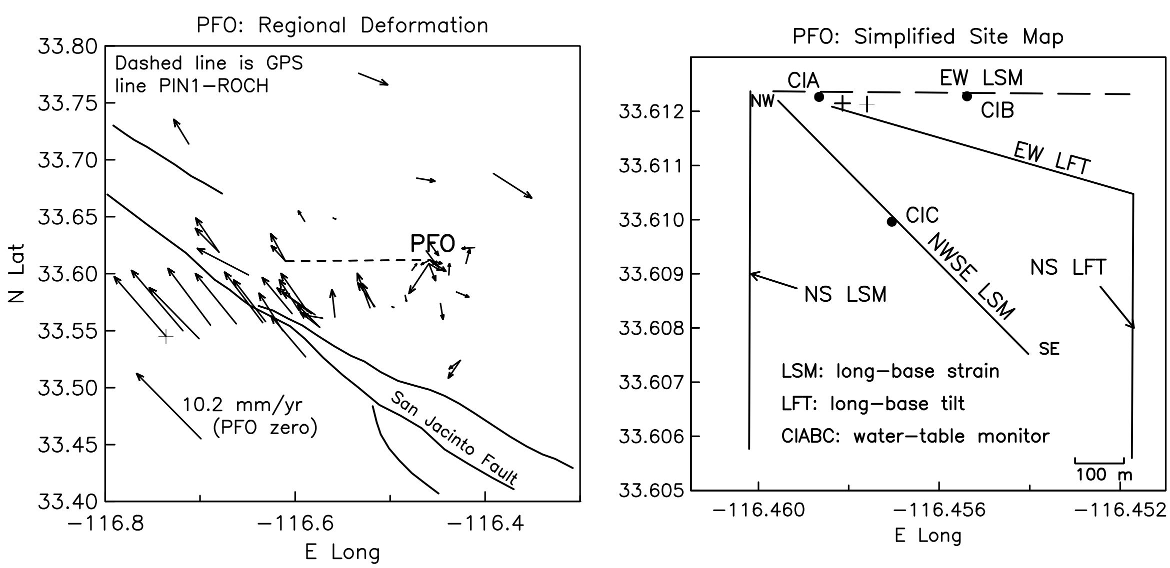

Figure 1

Figure 1 shows (left) an expanded view around PFO, including velocities of geodetic sites relative to PFO, from the SCEC Crustal Motion Map. As expected in this region of strike-slip faults, the predominant motion is simple shear; the local velocity gradient of $2.4 \times 10^{-7}\ \mathrm{yr}^{-1}$, agrees with the expected deformation from the two nearest active faults. The closest is the San Jacinto fault zone, 14 km SW of PFO. The geological slip rate is 11-12 mm/yr, though the geodetic data suggest a higher rate (B. Hager, pers. commun.). **Figure 1** (right) shows a site plan for PFO, named for Pinyon Flat, a large flat area of shallowly weathered granodiorite.

This grant supports the ongoing provision of high-quality and timely records of deformation fluctuations by running the long-base instruments and making ancillary measurements. It also helps to provide facilities that serve as a shared resource for the development and testing of emerging new technologies of geophysical interest. Having the components of PFO in place (land, power, shelters, recording) makes this much easier and less expensive than would otherwise be the case. All this is covered through funds for power, replacement parts, and salaries of technical staff; it is only a part of the PFO support, with other funds coming from the Scripps Director's Office and the Southern California Earthquake Center.

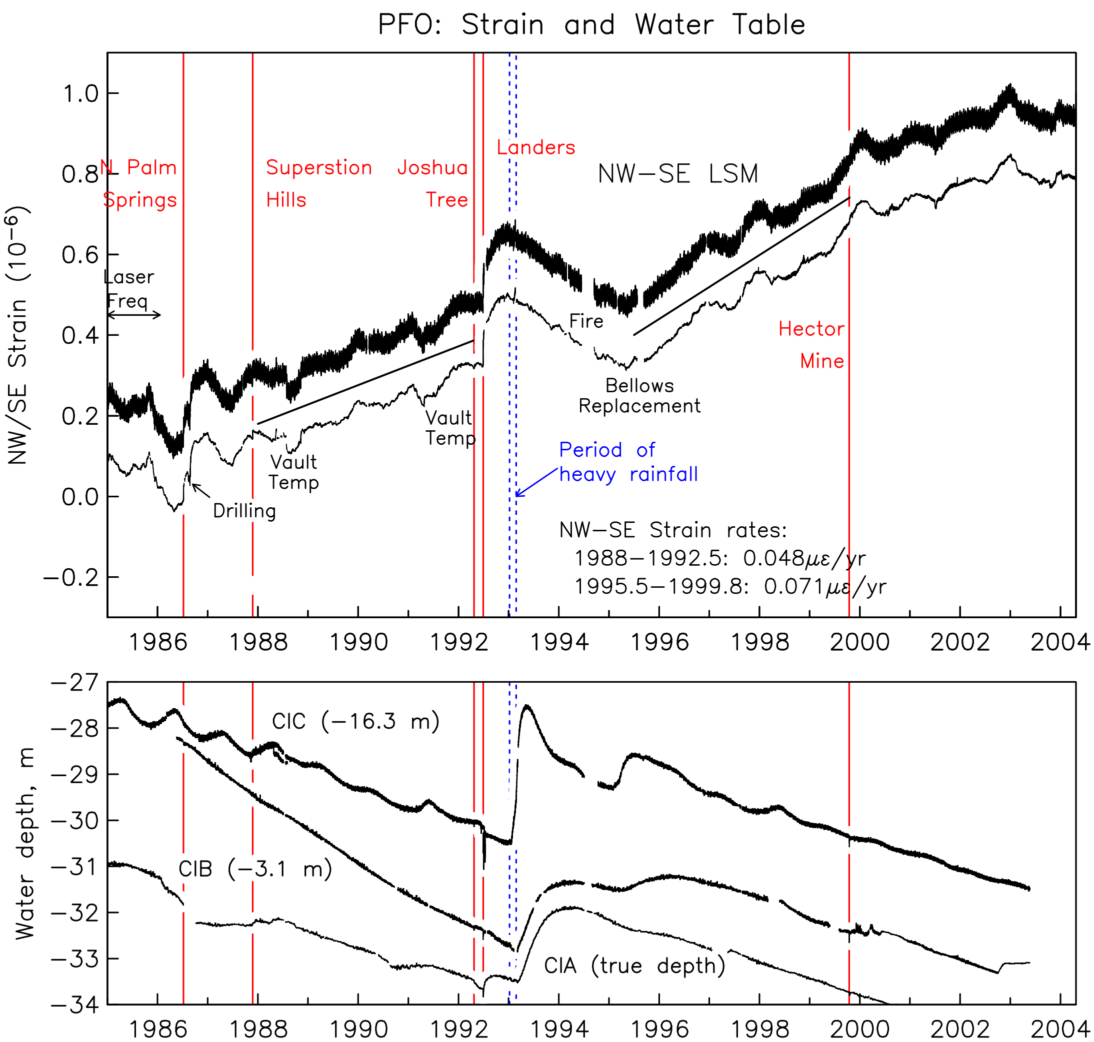

Figure 2

2. Observatory Activities

For PFO, **Figure 2** shows the long-term signal for the NWSE strainmeter: the only well-anchored instruments over this whole time. The "bump" after 1992.5 is a long-term postseismic strain from the Landers earthquake. The apparent offset at the time of this shock is actually rapid aseismic strain accumulation, which began immediately after the event and for the first six months was roughly proportional to the log of the elapsed time. In late 1992 the strain rate reversed sign, which lasted until 1995, to about the point at which the immediate post-seismic strains had been completely recovered. In 1996, the rate returned to approximately its preearthquake value; it has become clear that the post-Landers rate is noticeably higher, though the most recent data suggests that it has decreased following the Hector Mine shock. Records from the EW longbase tiltmeter show a similar signal, though they are somewhat noisier than the strainmeter, largely because of having to use an optical anchor using optical fibers (more affected by temperature); the agreement rules out instrumental problems. Following very large rainfalls in early 1993, well-level records at 3 locations at PFO (locations on **Figure 1**) show very large and rapid water-table changes with no response by the strainmeter or tiltmeter. This null result rules out, we believe, the possibility that the postseismic signals were caused by local pore-pressure changes.

Figure 3 shows the long-term strain at PFO for three different kinds of sensors: the laser strain data from a fully-anchored instrument; GPS (over the 14-km line from the GPS site at PFO (PIN1) to ROCH, 14 km away (actually set up as part of the PFO project in 1991); and the borehole strainmeter operated at PFO since 1982 by Dr. Mike Gladwin (CSIRO Australia). Because of problems with one of the sensors for this last instrument, we show only the one component closely aligned to the NWSE azimuth; detailed modelling (Hart *et al.* 1996) shows that this approximates the NW-SE far-field strain. We have also detrended the borehole data for clarity. We believe that this figure shows the unique capability of the longbase instrument to provide, as GPS does, reliable strain rates over very long terms, while still offering the ability to resolve much smaller changes over shorter times, which it shares with the borehole sensor. And no method other than the longbase sensor could have detected the “post-Landers bump”.

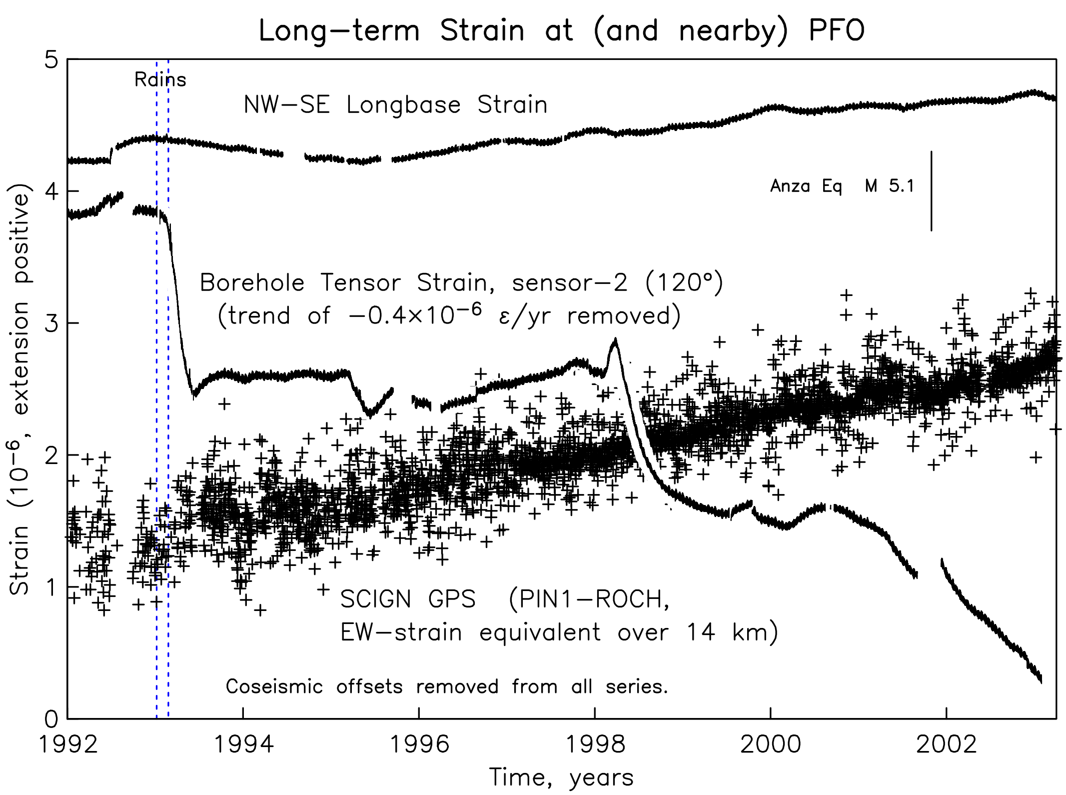

Figure 3

Operation of the observatory was largely uneventful during this period; we did not face any major difficulties with the facility, which is unusual.

The major change in this period was work on the EW laser strainmeter at Piñon, which we were funded (by NSF) to rebuild: in particular, installing optical anchors at both ends of the instrument (by now the only unanchored laser strainmeter). This rebuild also included a number of design improvements that we have made in the process of building new systems in Glendale (as part of the SCIGN project) and at Yucca Mountain (with DOE funding). The system was turned off on 2001:207; we began removal of the existing structures in spring 2002, and the anchors were grouted in place in October 2002. The system was completed and recording resumed on 2003:303.

Another improvement (in progress) will provide better access to data from PFO. The HP/WREN project (a joint effort between IGPP La Jolla and the San Diego Supercomputer Center; hpwren.ucsd.edu) is providing wireless Internet connections to remote sites around San Diego, while RoadNet is an NSF-funded project at IGPP to integrate remote field sensors into a seamless data-transfer system (roadnet.ucsd.edu). These two projects are providing a 45 Mb/s wireless Internet connection at PFO—obviously, a major contribution. We will be installing Internet-compatible data recorders at PFO: a PC-based system we developed for the Yucca Mountain project. We have requested funds from NSF Instruments and Facilities to interface these with the long-base strainmeters, to provide automated and remote control of a number of system functions: something we have now at Glendale and Yucca Mountain, and which greatly improves the operation of the systems.